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Comparison of Forage Digestion by Cattle and Horses

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TECHNICAL REPORT : COMPARISON OF FORAGE DIGESTION BY CATTLE AND HORSES

ABSTRACT

Two trials were conducted which compared digestion of Saskatchewan grown hays by cattle and horses. Altai wildrye, smooth bromegrass, crested wheatgrass, Kentucky bluegrass, oat and reed canarygrass hays were fed to six Hereford steers and six crossbred geldings in the first study. The second study compared digestion of alfalfa hay and dehydrated alfalfa pellets by these same animals. The voluntary dry matter intake (VDMI) of hay by cattle depended on neutral-detergent fiber (NDF) content. No single nutrient reliably predicted VDMI by horses. In the first study, cattle and horses had the highest VDMI for bromegrass hay. In trial 2, cattle ate similar amounts of dehydrated alfalfa pellets and alfalfa hay but the horses ate 17% more alfalfa hay than of the dehydrated alfalfa pellets. Cattle digested 25 to 35% more fiber than horses which accounts for their higher dry matter (DM) and energy utilization from forages. The voluntary energy intake from eating hay exceeded maintenance needs of the cattle and horses except when cattle were fed reed canarygrass hay. The true crude protein (CP) digestibility and metabolic fecal protein excreted by cattle and horses fed hay, respectively, were estimated at 83.4 and 80.3%, and 2.67 and 2.17 g/100 g DM intake. Horses digested more Ca (75%) than P (20%), while cattle digested more P (76%) than Ca (33%). Endogenous fecal Ca excretion was assessed at 6 and 22 mg/kg bodyweight (BW) for cattle and horses while endogenous fecal P excretion was 13 and 10 mg/kg BW for cattle and horses, respectively. In vitro organic matter digestibility was more reliable for predicting in vivo DM digestion by horses than by cattle. The poor repeatability of this technique invalidates its usefulness as a predictor of DM digestibility by horses.

BACKGROUND AND OBJECTIVES

Domestic livestock use the nutrients of forages with varying efficiencies. In digestion studies comparing horses and cattle, cattle are usually more efficient at digesting the fibrous components of hays than are horses. Yet, the extent to which horses and cattle differ in digesting forage nutrients depends on the type of hay and its processing. For example, horses utilize legume hays such as alfalfa with comparable efficiency to cattle, yet as the fiber content of the hay increases horses digest progressively less of these feeds than do ruminants. Prediction equations used in nutrition labs are largely based on data derived using cattle. These equations are sometimes applied to horses, although the anatomical and digestive differences of the bovine and equine digestive tracts are generally recognized to cause profound differences in how these animals digest feed. Thus many of these equations may be irrelevant for predicting digestibilities or deriving energy contents of hays for horses. Few studies have been reported in which cattle and horses were compared in their digestion of Saskatchewan-grown hays.

The aims of the following study were to compare the nutrient utilization and voluntary dry matter intake (VDMI) of Saskatchewan grown forages by steers and horses and to evaluate the usefulness of *in vitro* techniques and prediction equations for predicting feed utilization by cattle and horses.

EXPERIMENTAL METHODS

Two studies were conducted. In the first trial, six hays were fed to six ponies and six steers according to a 6 X 6 Latin square design. The six hays were: Altai wildrye (*Leysum angustus* Trin.), smooth bromegrass (*Bromus inermus* Leyss.), crested wheatgrass (*Agropyron cristatum* L. cv. Fairway), Kentucky

bluegrass (Poa pratensis L. cv. Troy), oat hay (Avena sativa L. cv. Harmon) and reed canarygrass (Phalaris arundinaceae L. cv. Frontier). The crested wheatgrass, Kentucky bluegrass and reed canarygrass were in advanced maturity and the Altai wildrye and bromegrass were in early maturity at harvest. Oat hay was reaped in early to mid-dough stage. Initially, this hay appeared well-cured, but it had a dense, coarse stem which underwent extensive mold growth during storage. Moldy bales were discarded. All hays were chopped to a minimum length of 10 cm using a tub grinder (John Deere 840, Moline, IL). A second study, using a switch back design and the same horses and steers, evaluated the VDMI and nutrient digestibility of alfalfa hay (Medicago sativa L.) and dehydrated alfalfa pellets (Canadian Dehydrators Association, Tisdale, Sask.).

Six Hereford steers (average weight, 221 kg) and six pony geldings (average weight, 334 kg) were used. Horses were dewormed with Eqvalan and cattle with Ivomec (MSD/Agvet) 4-weeks pre-trial. Steers were injected with 1 mL fat-soluble vitamin emulsion (Poten ADE). Horses were hand fed a fat-soluble vitamin pellet at the manufacturer's recommended rate (ADE Premix Pellets) During transitions to new diets, 30 g of a mineral supplement (Salt-Free 1:1 Mineral Plus) was provided daily.

Animals were fed hays to excess for a period of 12 to 14 days. The last 7 days of the period were used to establish VDMI. For 9 days thereafter, feed intake was restricted to 85% of voluntary intake. The last 4 days were used for total collection. Total fecal collections were made on steers and horses using metabolic crates which allowed separation of urine and feces.

Feed and feces were analyzed for dry matter (DM), gross energy (GE), crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), calcium (Ca) and phosphorus (P) by 1985 AOAC methods. In vitro organic matter

digestibilities were determined by the modified Tilley and Terry method.

Statistics included analysis of variance, regression and correlation analyses. Mean comparisons within species were made by Student-Newman-Keuls' procedure. Data were analyzed within and across species. The Lucas test, or the regression of digestible nutrient upon feed nutrient content, was used to predict endogenous nutrient excretion and true nutrient digestibility. Regression equations were compared by the method of Kleinbaum and Kupper.

RESULTS AND DISCUSSION

The nutrient compositions of the hays are given in Table 1. Hays were typical of these forage species grown in Saskatchewan and harvested at these stages of maturity. However, the reed canarygrass hay was low in GE and CP content. The quality of both alfalfa forages was considered above average based on nutrient composition.

The apparent nutrient digestibilities of the hays by horses and cattle are reported in Table 2. In trial 1, nutrient digestibilities except apparent CP digestibility were influenced by animal species and hay type. No period effects were observed except for NDF digestibility. Cattle digested more DM, GE, NDF and P but less Ca than horses. Horses and cattle used the CP from hays similarly but the amount digested depended on hay type. Horses and cattle digested DM, NDF and CP similarly but differed in their use of ADF, Ca and P from alfalfa forages.

Cattle digested more DM from Altai wildrye, bromegrass, oat and Kentucky bluegrass hays than from the crested wheatgrass and reed canarygrass hays. The same pattern of DM digestion existed for horses except that Kentucky bluegrass was not as well digested as wildrye, brome or oat hays. Cattle digested more

DM from alfalfa hay than from dehydrated alfalfa pellets while horses had similar DM digestibilities for both legume feeds. Forage DM digestibilities accurately predicted GE digestibilities by cattle and horses (Table 3).

Voluntary DE intakes by cattle and horses are given in Table 4. Data on net and metabolizable energy conversions for horses are limited. Thus, cattle and horses were only compared for DE intakes. In all instances, DE intakes by cattle were higher, perhaps indicating their higher energy requirements or a gut size limitation of the horses. The net energy needed for maintenance of cattle was calculated on the basis of NRC (1984) equations and exceeded maintenance requirements except when reed canarygrass hay was fed. The subnormal energy intake by cattle fed this hay resulted from its low voluntary intake and low digestibility.

The ADF and NDF digestibilities of all hays are given in Table 2. In trial 1, cattle digested 25 to 35% more NDF and ADF than the horses. Both species digested the NDF of the long and pelleted alfalfa, and the ADF of the alfalfa pellets similarly, yet cattle digested substantially more ADF from alfalfa hay than did horses. The values for ADF digestibility obtained here for cattle were 10 percentage units greater than those in recent reports.

Previous studies have shown that horses digest more DM from legume than from grass hays. However, this depends on plant maturity at harvest and consequently, fiber content. The higher DM digestibility of brome by horses compared to other grass hays may be due to its higher mesophyll content which is more easily digested by horses. Horses may be unable to digest highly fibrous hays as well as cattle because the numbers and cellulolytic activity of equine cecal-colonic microflora are lower than those found in the bovine rumen. Horses also have a more rapid rate of passage than cattle. Pelleted

feed has a shorter retention time than long hay for cattle and horses which may explain the lower ADF digestibility of pelleted than long alfalfa hay.

Sheep digest more long hay than pelleted alfalfa because the they sort the hay and eat only the palatable portions. Since no refusals occurred in this study, sorting does not explain the different digestibilities of long and dehydrated alfalfa by cattle. A higher fiber digestibility of the long hay may contribute to its higher DM digestibility (Table 2).

Generally, cattle and horses digest similar amounts of CP from feeds. Except for three forages, our data support this statement (Table 2). Horses digested more CP from oat and reed canarygrass hays, but less from crested wheatgrass hay, than cattle. The Lucas test was used to predict metabolic fecal protein (MFP). The equation obtained for cattle was $Y = 0.834\ X - 2.67$ ($R^2 = 0.986$) where Y is percentage digestible CP and X is percentage forage CP. For horses, the equation was $Y = 0.803\ X - 2.17$ ($R^2 = 0.976$). These equations indicate that MFP was 2.67 and 2.17 g/100 g DM intake or 0.427 and 0.347 g nitrogen/100 g DM intake for cattle and horses, respectively. The values for MFP of cattle and horses differ (Table 5).

Metabolic fecal protein can account for protein losses of 0.8 to 5.0 g CP/100 g DM intake in domestic ruminants fed forages. Generally, horses are believed to have a lower MFP than cattle but estimates vary. Horses fed hay diets are reported to have a MFP of 2.4 and 3.3 g/100 g DM intake. The estimated true protein digestibilities from forages in the present study were similar at 83.4% and 80.3% for cattle and horses, respectively. These values agree with those reported by others.

Horses digested comparatively high amounts of CP in view of the low DM digestibility of the grass hays. Apparent CP digestibilities were directly

related to forage CP content but negatively related to NDF content (Table 3). Horses had low apparent CP digestibilities when fed the crested wheatgrass hay which may have been due to a non-infectious diarrhea seen with feeding of this hay (see below). Cattle had low CP digestibilities on diets of oat, crested wheatgrass or reed canarygrass hay that may have arisen from the low feed and CP intakes of these feeds (Table 2). Low energy intakes (Table 4) associated with these diets could impair proteolytic activity by ruminal microflora.

The digestion of forage minerals by cattle and horses are given in Table 2. Differences existed between animal species and among forages. Generally, horses digested more Ca but less P than cattle which is consistent with previous reports. Large between animal variations were evident in Ca and P digestibility but are not unusual in mineral studies of cattle and horses.

Endogenous fecal mineral excretion was estimated by regression of total mineral intake/kg BW versus total absorbed mineral/kg BW. The endogenous fecal Ca and P excretions for cattle were estimated to be 6.5 and 13.3 mg/kg BW, respectively. Endogenous fecal losses by cattle of similar weight can be inferred from ARC (1980) data to be 10 mg Ca and 20 mg P/kg BW. By contrast, the values for endogenous fecal Ca and P for horses were found to be 22.1 and 10.2 mg/kg BW, respectively, and agree with the estimates made for horses by isotopic methods. True Ca digestibilities by horses and cattle were estimated to be 75 and 20%, respectively. The true P digestibilities by horses and cattle were estimated at 32.6 and 75.6%, respectively. These values compare favorably with published values and emphasize the need to heed species difference in mineral utilization when considering dietary mineral adequacy.

The VDMI were calculated per 100 kg BW and per unit metabolic body size ($BW^{0.75}$) (Table 4). VDMI differed with forage and with animal species. More

bromegrass was eaten by horses and cattle than of any other hay in trial 1. As a result, voluntary DE intake by cattle and horses fed brome was 28 to 72% greater than for the other hays although it was less than DE intakes on legume diets. Absolute intakes of the other five hays in trial 1 varied between horses and cattle. Horses ate more reed canarygrass than Altai wildrye, Kentucky bluegrass, crested wheatgrass and oat hays (81 to 85 g/$BW^{0.75}$) (Table 4). Cattle had the highest VDMI for bromegrass, followed by crested wheatgrass, Altai wildrye and oat hays. The poorest intake occurred for cattle fed reed canarygrass hay although Kentucky bluegrass was also poorly consumed.

Reed canarygrass can be unpalatable to horses and cattle because of a high alkaloid content. But since the alkaloid content of reed canarygrass decreases with plant maturity, the content was predicted to be low and was not expected to affect palatability of this hay in the present study. However, cattle had a poor intake of the reed canarygrass while horses ate substantial amounts (Table 4). Alkaloids may still account for the reduced palatability of the reed canarygrass hay by cattle, but other causes of intake suppression may explain VDMI differences between cattle and horses fed this hay. These include silicification of reed canarygrass or the high cell wall content of this hay. A more likely cause is reduced microbial viability due to subnormal energy and protein intakes associated with feeding reed canarygrass. Predicted net energy intakes by cattle fed reed canarygrass was 80% of maintenance (data not shown). This low intake would suppress microbial function.

Horses ate more long alfalfa than dehydrated alfalfa pellets while cattle ingested the same amounts of both legumes. Intakes of dehydrated alfalfa by cattle agreed with amounts described by others. Previously, horses were found to eat more pelleted than long alfalfa hay, yet the opposite was found here.

However, dehydrated alfalfa was used herein rather than a pelleted form of the alfalfa hay. The different intakes of dehydrated alfalfa and alfalfa hay may relate to physical properties of the pellets or the high acceptability of the alfalfa hay. Considerable individual variation (CV = 12.5%) occurred in VDMI of both alfalfas by cattle and horses. Voluntary DE intakes greatly exceeded maintenance needs when legume hays were fed (Table 4).

Depending on hay type, forage VDMI by cattle is directly related to DM digestibility while DM intake and digestibility are negatively related to ADF and NDF content. The response curve between DM intake and NDF content may be finite. That is, beyond a point, the DM intake-NDF relationship may become unreliable because gut fill becomes the limiting factor. The equations derived by Reid et al. (1988) to predict DM intake based on ADF and NDF reliably predicted DM intake by cattle in the present study. However, ADF was slightly more accurate than NDF for predicting DM intake based on our data (Table 3). NDF differs among forages which can cause different rates of degradation and turnover time, or can alter gut fill characteristics. NDF intakes herein were similar between animal species but varied with forage type (data not shown). If NDF intake dictates gut fill, then horses are more like cattle than sheep in their gut fill limitations. This appears to occur despite different retention times and rates of passage between cattle and horses.

Cattle resisted eating the mature stems of the reed canarygrass, the Altai wildrye and the oat hays even when restricted to 85% of voluntary feed intake. All animals sorted the oat hay when it was fed ad libitum yet the coefficient of variation (CV) for voluntary intake was less than 6%. When intake was restricted, half of the horses and cattle ate the entire offering of oat hay while the other half refused portions of straw. All of the steers ate the

crested wheatgrass at 85% voluntary feed intake but only half of the horses entirely consumed their daily allotment at the restricted intake.

A profuse, watery feces occurred in the horses 8 to 10 days after the onset of feeding diets of crested wheatgrass and oat hays. Fecal moistures for horses fed crested wheatgrass and oat hays were 81 and 80.8%, respectively, (Table 6), which exceeded fecal moistures produced by other hays. The wettest feces for steers occurred when oats and Kentucky bluegrass hays were fed.

Water intake by horses was similar whether alfalfa or grass hays were fed (Table 6). However, water intakes were highest when the two hays that caused the profuse watery diarrhea were fed. Urine production was twice as high for horses and cattle fed alfalfa hay compared to urine outputs when grass hays were fed. This observation is consistent with those previously made for horses fed legume diets. As expected, cattle had wetter feces than horses.

The in vivo DM digestibilities of forages by cattle and horses are compared to in vitro OM digestibilities in Table 7. Repeatability was poor for the in vitro technique. Furthermore, in vitro OMD had a low predictability for estimating DM digestibility by cattle. The error in estimating DM digestion from in vitro OMD for cattle varied from 3.5 to 64% (average error, 34.6%) and was the least effective in predicting digestion of grass hay. The error in predicting equine DM digestion from in vitro digestion was 0.1 to 31.3% (average error, 11.2%). However, the in vitro technique was not sufficiently repeatable to justify use of this method for predicting DM digestibility of forages by horses. Differences in donor inoculum arising from diet and age variation may account for the low repeatability of the in vitro method.

No digestive problems developed in the cattle or horses in either trial but all horses exhibited extensive wood-chewing when fed either alfalfa forage.

Causes of wood-chewing in horses include mineral deficiency, boredom or a lack of dietary fiber especially on pelleted diets. Horses chewed wood when fed long alfalfa hay ad libitum which discounts all of these causes. Wood-chewing appeared to be associated with inactivity and was compounded by high energy intakes. This implies that frustration rather than boredom may be a cause and is supported by the absence of this vice when marginal quality grass hays were fed. Wood-chewing is a variant stereotypy of crib-biting or cribbing which has been associated with feeding and with high energy diets. Cribbing and highly palatable diets may induce B-endorphin and dopamine production which becomes a pleasureable and reinforceable activity. Perhaps, highly digestible diets such as alfalfa hays invoke the same neurochemical production thereby initiating a biochemical rather than a behavioral vice.

CONCLUSIONS AND IMPACT

1. Digestion data for cattle and horses are not alike. For example, energy digestibilities of high-quality hays (alfalfa) differed between horses and cattle by only 2 to 5% but differed by 10 to 15 percentage units when low-quality hays were fed. This underlines the fact that nutritional data for horses cannot be inferred from cattle. These data must be collected using horses. There is virtually no data which describes digestibility of Saskatchewan feeds by horses.

2. The nutritive value of alfalfa forages for cattle and horses was twice that for oat or grass hays. It is more economical to purchase a high-quality, albeit more costly alfalfa hay than to buy a poor-quality, cheap hay for horses because alfalfa hays have a much higher nutrient digestibility and are

consumed in greater amounts than grass or oat hays.

3. A drawback of the high energy and nutrient digestibility of alfalfa forages, however, is that feed intakes of these hays must be controlled for overweight, mature horses. Use of a good quality grass hay is advisable in these instances. The high digestibility of the energy, crude protein and calcium of alfalfa forages makes them ideal roughages for growing stock whether it is horses or cattle.

4. Bromegrass was a highly palatable hay for both cattle and horses which increased its nutritive value. Brome is suitable for mature horses but its nutrient density may be too low for growing horses (less than one year of age). None of the other grass hays or the oat hay were nutritionally useful for growing horses.

5) Energy values for hays which are derived from currently used prediction equations based on fiber content of feed apply only to cattle. Whereas horses digest the fiber from alfalfa similarly to cattle, they digest 25-35% less fiber from grass hays. Energy values for grass hays using cattle derived equations must be multiplied by 0.66 to apply to horses. Extreme errors in ration formulation are made if values are not corrected for variations between cattle and horses in energy, fiber or mineral use from hays.

6) The low content and low digestibilility of calcium and phosphorus in grass hays grown in Saskatchewan requires that supplemental calcium and phosphorus be given consistently if these feeds are the sole ingredient of the diet. A

1:1 calcium-phosphorus supplement is needed by both horses and cattle.

7) Horses overwintered on poor-quality (or good-quality) hay require substantial amounts of water (5 to 10 gallons daily). This amount of water cannot be acquired by eating snow.

8) Horses fed alfalfa urinate twice as much as when fed grass hays. From a husbandry standpoint, more bedding is needed for horses fed alfalfa diets than grass hay diets.

9) <u>In vitro</u> organic matter digestibility is not a reliable nor a repeatable technique for predicting digestibility of hays by horses or cattle. This is a costly method yet had an error of 0.1 to 31% for horses and 3.5 to 64% for cattle in predicting hay digestibility.

10) Poor-quality, highly fibrous hays fed free-choice resulted in less wood-chewing than alfalfa hays, including long alfalfa. Small amounts of long, grass hays may be useful in minimizing this vice in chronically-stabled, mature horses fed alfalfa hay or pellets free-choice.

Table 1. Nutrient Composition of Hays Used in the Study (Dry Matter Basis)

Forage	Gross energy (Mcal kg^{-1})	ADF (%)	NDF (%)	Crude protein (%)	Calcium (%)	Phosphorus (%)
Trial 1						
Altai wildrye	4.31	48.4	74.9	6.8	0.4	0.10
Bromegrass	4.42	35.6	59.5	10.5	0.56	0.10
Crested wheatgrass	4.34	42.7	68.9	5.7	0.37	0.14
Kentucky bluegrass	4.34	45.9	72.7	11.3	0.46	0.11
Oats hay	4.34	45.7	68.5	7.2	0.34	0.16
Reed canarygrass	4.16	44.8	65.5	5.9	0.42	0.07
SE	0.04	0.5	0.6	0.3	0.01	0.004
Trial 2						
Alfalfa hay	4.44	31.2	41.4	20.9	1.30	0.20
Dehydrated alfalfa	4.42	28.9	43.9	22.1	1.93	0.23
SE	0.03	0.3	0.2	0.2	0.07	0.004

Table 2. Apparent nutrient digestibilities (%) of forages by cattle and horses

Forage	Species	Dry matter	Gross energy	Acid detergent fibre	Neutral detergent fibre	Crude protein	Calcium	Phosphorus
Trial 1								
Altai wildrye	Cattle	58.8a	56.4ab	53.2ab	64.0a	50.4b	27.2[b]	-5.0a
Bromegrass		59.7a	57.7a	42.7c	61.5ab	54.7a	34.9a	-4.7a
Crested wheatgrass		54.7b	52.2bc	43.6c	55.3b	40.8c	37.4a	18.8a
Kentucky bluegrass		60.3a	58.9a	56.0a	66.5a	55.8a	28.7b	4.7a
Oats hay		59.6a	57.9a	52.5b	60.4b	44.7b	36.6a	21.4a
Reed canarygrass		50.0c	49.8c	38.4d	50.8c	41.0bc	20.8c	-48.2b
SE		0.7	0.7	1.2	1.2	1.5	2.7	4.4
Altai wildrye	Horses	47.0a	44.2ab	39.4a	49.9a	53.6b	45.2b	-27.4a
Bromegrass		47.7a	45.2ab	29.1b	44.4b	50.9b	56.2a	-1.9a
Crested wheatgrass		42.1bc	40.5bc	25.8bc	40.6c	29.2c	29.4d	-22.8a
Kentucky bluegrass		44.8b	44.4ab	39.7a	50.8a	59.3a	39.0c	-50.8b
Oats hay		47.5a	46.8a	36.9a	44.3b	59.6a	27.8d	-24.8a
Reed canarygrass		38.5c	38.4c	21.1d	33.7d	51.6b	46.9b	-37.4a
SE		0.8	0.7	1.4	1.1	2.1	2.1	5.5
Trial 2								
Alfalfa hay	Cattle	66.4a	65.1a	53.0a	54.2a	74.3a	11.5b	55.2a
Dehydrated alfalfa		60.8b	60.5b	36.9b	49.3b	69.2b	26.6a	46.3b
SE		0.9	0.8	2.6	0.9	0.9	2.6	2.0
Alfalfa hay	Horses	64.4	59.6	42.5a	50.7a	71.7a	65.0a	15.6a
Dehydrated alfalfa		62.8	58.6	37.9b	49.4a	69.7a	69.5a	-4.6b
SE		0.8	0.9	2.3	1.0	1.2	2.1	5.5

a-b Values in a column and trial with different superscripts differ at P 0.05.

Table 3. Equations describing the relationship of forage composition (%) to forage nutritive value for cattle and horses

Species	Dependent Value	Independent Value	Regression Equation	R2
Cattle	Voluntary DM intake, ($g/BW^{.75}$)	NDF content, %ƒ	171.5 - 1.33 X	0.626
		ADF content, %ƒ§	183.7 - 2.35 X	0.663
	DE intake, ($kcal/BW^{.75}$)	NDF content, %	516.6 - 4.66 X	0.669
		ADF content, %	549.5 - 7.96 X	0.663
		Crude protein, %	126.7 + 8.97 X	0.675
	Crude protein digestibility, %	Crude protein, %	32.8 + 1.84 X	0.752
		NDF content, %	105.0 - 0.83 X	0.560
	Gross energy digestibility, %	Dry matter§ digestibility, %	-1.1 + 0.99 X	0.934
	DE content (Mcal/kg)	ADF content, %	3.3 - 0.019 X	0.311
Horses	Dry matter intake, ($g/BW^{.75}$)	NDF content, %ƒ	145.9 - 0.84 X	0.266
		ADF content, %ƒ§	153.3 - 1.46 X	0.270
	Voluntary DE intake, ($kcal/BW^{.75}$)	NDF content, %	469.5 - 4.43 X	0.642
		ADF content, %	495.4 - 7.43 X	0.598
		Crude protein, %	108.2 + 7.75 X	0.552
	Crude protein digestibility, %	Crude protein	38.4 + 1.56 X	0.478
		NDF content, %	97.5 - 0.67 X	0.317
	Gross energy digestibility, %	Dry matter§ digestibility, %	5.5 + 0.84 X	0.971
	DE content, Mcal/kg	ADF content, %	3.7 - 0.042	0.593

ƒ Slopes of equations for identical comparisons of cattle and horses differ ($P<0.05$).

§ Intercepts of equations for identical comparisons of cattle and horses differ ($P<0.05$).

Table 4. Voluntary feed intake of selected forages by cattle and horses

Forage	Dry matter intake, (g DM/kg BW$^{.75}$)		Dry matter intake, (kg DM/100 kg BW)		Digestible energy intake, (Mcal/ 100 kg BW)	
	Cattle	Horses	Cattle	Horses	Cattle	Horses
Trial 1						
Altai wildrye	80.9bc	81.2c	2.06c	1.92c	4.99b	3.68b
Bromegrass	100.1a	113.6a	2.56a	2.68a	6.49a	5.42a
Crested wheatgrass	85.7b	85.0c	2.19b	2.01c	4.90b	3.58b
Kentucky bluegrass	72.0d	82.3c	1.84d	1.96c	4.66bc	3.71b
Oats hay	74.9cd	81.2c	1.92cd	1.93c	4.81bc	3.89b
Reed canarygrass	71.3d	99.4b	1.83d	2.36b	3.77c	3.82b
SE	2.2	2.9	0.06	0.07	0.19	0.15
Trial 2						
Alfalfa hay, long	120.8	114.4a	2.96	2.70a	8.08	6.89
Dehydrated alfalfa pellets	114.3	97.9b	2.79	2.30b	7.06	5.83
SE	4.4	5.6	0.09	0.11	0.31	0.34

a-d Values in a column and trial with different superscripts differ ($P<0.05$).

Table 5. Lucas testsa of forage components by horses and cattle

Component (X)	Species	Equation	R2
Crude protein*f*	Cattle	.834 X - 2.67	0.986
	Horses	.803 X - 2.17	0.976
NDF*f*§	Cattle	.766 X -11.12	0.833
	Horses	.408 X + 2.70	0.564
ADF*f*§	Cattle	.636 X - 6.49	0.714
	Horses	.287 X + 2.04	0.226

a Based on regression of percentage forage component on percentage digestible component.

f The intercept of the equation for horses and cattle differs ($P<0.05$).

§ The slope of the equations for cattle and horses differs ($P<0.05$).

Table 6. Effects of type of forage consumed on water intake of horses, fecal water, urine production and fecal moisture of cattle and steers

Forage	Horses				Cattle		
	Water Intake	Fecal Water	Urine	Fecal Moisture	Fecal Water	Urine	Fecal Moisture
	----(l/kg DM intake)----			--(%)---	(l/kg DM intake)		---%----
Trial 1							
Altai	3.21b	1.75c	0.99a	76.4b	1.75c	1.30a	80.7b
Bromegrass	2.76c	1.64c	0.59c	75.8b	1.67c	1.07b	80.2b
Crested wheatgrass	3.47a	2.50a	0.57c	80.8a	1.73c	1.19ab	78.7b
Kentucky bluegrass	3.15b	1.86bc	0.78b	77.0b	2.19a	1.03b	84.5a
Oats hay	3.65a	2.50a	0.79b	81.0a	2.14a	1.12b	84.7a
Reed canarygrass	2.88c	2.00b	0.56c	77.6b	2.01b	0.82c	80.0b
Trial 2							
Long alfalfa hay	3.27a	1.21a	1.48a	77.5a	1.56a	2.09a	82.1a
Dehydrated alfalfa pellets	3.27a	1.12a	1.69a	74.7b	1.49a	1.79b	78.9b

a Values within a column and within a trial with different superscripts differ ($P<.05$).

Table 7. Comparison of in vivo dry matter digestibilities of forages by horses and cattle with in vitro organic matter digestibilities

Forage	In Vitro OMD		In Vivo DMD	
	1	2	Horses	Cattle
Altai wildrye	41.0	35.8	47.0	58.8
Bromegrass	50.3	45.7	47.7	59.7
Crested wheatgrass	42.4	35.5	42.1	54.7
Kentucky bluegrass	40.8	38.1	44.8	60.3
Oats	43.3	36.9	47.5	59.6
Reed canarygrass	38.2	36.3	38.5	50.0
Long alfalfa	64.1	54.3	64.4	66.4
Dehydrated alfalfa	63.2	55.5	62.8	60.8

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